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SPEECH PROCESSING FOR TELEPHONY API

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SPEECH PROCESSING FOR TELEPHONY API

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Related Applications

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Technical Field

This invention relates generally to computer telephony, and more particularly to speech processing for computer telephony.

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With the advent of computer networking, such as local-area networks (LAN), wide-area networks (WAN), intranets and the Internet, several applications have become popularized. In one such application, a user of a first client computer is able to "call" and communicate with a user of a second client computer. This type of application is generally known as computer telephony.

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To accommodate computer telephony, operating systems such as versions of the MICROSOFT WINDOWS operating systems include telephony application

5 programming interfaces, or TAPI's. (It is noted that TAPI typically refers
specifically to Microsoft's Telephony API and is not usually used in reference to
other telephony API's. However, as used in this application, TAPI refers to
telephony API's generically.) Application programming interfaces (API's) are
interfaces by which computer programs can provide for specific functionality that
10 is included within the operating systems. This means that programmers
developing such programs do not have to develop their own code to provide this
functionality, but rather can rely on the code within the operating system itself.
Thus, a TAPI relates to a computer telephony application programming interface.

In the MICROSOFT WINDOWS 95 operating system, as well as other
15 versions of the MICROSOFT WINDOWS operating system, TAPI version 2.1
provides for some basic computer telephony functionality for utilization by
computer programs. In particular, TAPI 2.1 provides for call control -- the
initiation and termination of computer telephony calls. However, call control is
only one aspect of computer telephony. For example, once a computer telephony
20 call is placed, the media aspects of the call must also be controlled. However,
TAPI 2.1, as well as other prior art telephony API's, do not provide for this
functionality.

The media aspects of the call relate to the information (or, media) that is
itself the subject of the call. For example, a voice call includes audio information
25 transmitted by both the caller and callee of a call, a video call includes both audio
information and visual (video) information, etc. Currently, any multimedia
devices that are to be used in conjunction with a computer telephony call -- such as
microphones to detect sound, and speakers to play sound -- must have specific
drivers written for this purpose, to be used specifically in conjunction with
30 computer telephony calls. Other multimedia devices that may be present, in other
words, may not be usable in conjunction with the call.

TAPI 2.1, as well as other prior art telephony API's, are also represented

5 as a framework that is not easily expanded. For example, TAPI 2.1 is procedurally based, which means the API cannot easily accommodate new aspects and features without redeveloping the entire API. For the reasons outlined in this background, as well as other reasons, there is, therefore, a need for the present invention.

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Summary

The above-identified problems, shortcomings and disadvantages with the prior art, as well as other problems, shortcoming and disadvantages, are solved by the present invention, which will be understood by reading and studying the
15 specification and the drawings. In one embodiment, a system includes at least one call control object and at least one media control object. The call control objects are to initiate and terminate a computer telephony call having a media stream. The media control objects are to end-point the media stream of the computer telephony call. In a further embodiment, there is also a media control manager to
20 instantiate a media control object for each multimedia device of the system.

Thus, embodiments of the invention provide for advantages not found in the prior art. The invention provides for well-defined media control: besides call control objects, embodiments of the invention include media control objects to end-point (for example, source or sink) the media stream of a computer telephony call. The invention provides for the utilization of multimedia devices (including virtual devices as well as physical devices) that may not have been installed specifically for telephony purposes, via the media control manager instantiating media control objects for such devices. Furthermore, the invention provides for an object-based hierarchy to TAPI's (e.g., via the call control objects and the
25 media control objects), to maximize flexibility and further expansion of TAPI's
30 based on the invention.

The invention includes systems, methods, computers, application

5 programming interfaces, and computer-readable media of varying scope. Besides the embodiments, advantages and aspects of the invention described here, the invention also includes other embodiments, advantages and aspects, as will become apparent by reading and studying the drawings and the following description.

10

Brief Description of the Drawings

Figure 1 shows a diagram of the hardware and operating environment in conjunction with which aspects of the invention may be practiced.

15 Figure 2 shows a block diagram of an object hierarchy according to one aspect of the present invention.

Figure 3 shows a block diagram of an architecture according to one aspect of the present invention.

Figure 4(a) shows a method for placing an outgoing computer telephony call according to one aspect of the present invention.

20 Figure 4(b) shows a method for receiving an incoming computer telephony call according to one aspect of the present invention.

Figure 5 is a block diagram of a system according to one aspect of the present invention.

25 Figure 6 is a block diagram of a system according to one aspect of the present invention.

Figure 7 is a block diagram of a system according to one aspect of the present invention.

Figure 8 is an object diagram of a collection of objects according to one aspect of the present invention.

30 Figure 9 is a structural diagram of a data structure according to one aspect of the present invention.

Figure 10 is a process diagram of a method according to one aspect of the

5 present invention.

Figure 11 is a structural diagram of a data structure according to one aspect of the present invention.

Figure 12 is a process diagram of a method according to one aspect of the present invention.

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Detailed Description

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In the following detailed description of exemplary embodiments of the invention, reference is made to the accompanying drawings which form a part hereof, and in which is shown, by way of illustration, specific exemplary embodiments in which the invention may be practiced. In the drawings, like numerals describe substantially similar components throughout the several views. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, electrical, and other changes may be made without departing from the spirit or scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

20

Hardware and Operating Environment

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Figure 1 is a block diagram of a system according to one aspect of the present invention. Figure 1 provides a brief, general description of a suitable computing environment in which the invention may be implemented. The invention will hereinafter be described in the general context of computer-executable program modules containing instructions executed by a personal computer (PC). Program modules include routines, programs, objects, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Those skilled in the art will appreciate that the invention may be practiced with other computer-system configurations, including

- 5 hand-held devices, multiprocessor systems, microprocessor-based programmable consumer electronics, network PCs, minicomputers, mainframe computers, and the like, which have multimedia capabilities. The invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices linked through a communications network. In a distributed
- 10 computing environment, program modules may be located in both local and remote memory storage devices.

Figure 1 shows a general-purpose computing device in the form of a conventional personal computer 120, which includes processing unit 121, system memory 122, and system bus 123 that couples the system memory and other system components to processing unit 121. System bus 123 may be any of several types, including a memory bus or memory controller, a peripheral bus, and a local bus, and may use any of a variety of bus structures. System memory 122 includes read-only memory (ROM) 124 and random-access memory (RAM) 125. A basic input/output system (BIOS) 126, stored in ROM 124, contains the basic routines that transfer information between components of personal computer 120. BIOS 126 also contains start-up routines for the system. Personal computer 120 further includes hard disk drive 127 for reading from and writing to a hard disk (not shown), magnetic disk drive 128 for reading from and writing to a removable magnetic disk 129, and optical disk drive 130 for reading from and writing to a removable optical disk 131 such as a CD-ROM or other optical medium. Hard disk drive 127, magnetic disk drive 128, and optical disk drive 130 are connected to system bus 123 by a hard-disk drive interface 132, a magnetic-disk drive interface 133, and an optical-drive interface 134, respectively. The drives and their associated computer-readable media provide nonvolatile storage of computer-readable instructions, data structures, program modules, and other data for personal computer 120. Although the exemplary environment described herein employs a hard disk, a removable magnetic disk 129 and a removable optical disk

- 5 131, those skilled in the art will appreciate that other types of computer-readable media which can store data accessible by a computer may also be used in the exemplary operating environment. Such media may include magnetic cassettes, flash-memory cards, digital versatile disks, Bernoulli cartridges, RAMs, ROMs, and the like.
- 10 Program modules may be stored on the hard disk, magnetic disk 129, optical disk 131, ROM 124, and RAM 125. Program modules may include operating system 135, one or more application programs 136, other program modules 137, and program data 138. A user may enter commands and information into personal computer 120 through input devices such as a keyboard
- 15 140 and a pointing device 142. Other input devices (not shown) may include a microphone, joystick, game pad, satellite dish, scanner, or the like. These and other input devices are often connected to the processing unit 121 through a serial-port interface 146 coupled to system bus 123; but they may be connected through other interfaces not shown in Figure 1, such as a parallel port, a game port, or a
- 20 universal serial bus (USB). A monitor 147 or other display device also connects to system bus 123 via an interface such as a video adapter 148. In addition to the monitor, personal computers typically include other peripheral output devices such as a sound adapter 156, speakers 157, and additional devices such as printers.
- Personal computer 120 may operate in a networked environment using
- 25 logical connections to one or more remote computers such as remote computer 149. Remote computer 149 may be another personal computer, a server, a router, a network PC, a peer device, or other common network node. It typically includes many or all of the components described above in connection with personal computer 120; however, only a storage device 150 is illustrated in Figure
- 30 1. The logical connections depicted in Figure 1 include local-area network (LAN) 151 and a wide-area network (WAN) 152. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets and the

- 5 Internet.
- When placed in a LAN networking environment, PC 120 connects to local network 151 through a network interface or adapter 153. When used in a WAN networking environment such as the Internet, PC 120 typically includes modem 154 or other means for establishing communications over network 152. Modem
- 10 154 may be internal or external to PC 120, and connects to system bus 123 via serial-port interface 146. In a networked environment, program modules, such as those comprising Microsoft® Word which are depicted as residing within PC 120 or portions thereof may be stored in remote storage device 150. Of course, the network connections shown are illustrative, and other means of establishing a
- 15 communications link between the computers may be substituted.

Software may be designed using many different methods, including object-oriented programming methods. C++ is one example of common object-oriented computer programming languages that provide the functionality associated with object-oriented programming. Object-oriented programming methods provide a

20 means to encapsulate data members (variables) and member functions (methods) that operate on that data into a single entity called a class. Object-oriented programming methods also provide a means to create new classes based on existing classes.

An object is an instance of a class. The data members of an object are

25 attributes that are stored inside the computer memory, and the methods are executable computer code that acts upon this data, along with potentially providing other services. The notion of an object is exploited in the present invention in that certain aspects of the invention are implemented as objects in one embodiment.

An interface is a group of related functions that are organized into a named

30 unit. Each interface may be uniquely identified by some identifier. Interfaces have no instantiation, that is, an interface is a definition only without the executable code needed to implement the methods which are specified by the

5 interface. An object may support an interface by providing executable code for the methods specified by the interface. The executable code supplied by the object must comply with the definitions specified by the interface. The object may also provide additional methods. Those skilled in the art will recognize that interfaces are not limited to use in or by an object-oriented programming environment.

10

System

Figure 2 shows a block diagram of an object hierarchy according to one embodiment of the invention. Figure 3 shows a block diagram of an architecture according to one embodiment of the invention. In this section of the detailed 15 description, a description of a computerized system according to an embodiment of the invention is provided. The description is provided by reference to Figure 2 and Figure 3.

Referring first to Figure 2, an object hierarchy according to an embodiment of the invention is shown. The system includes a telephony 20 application programming interface object (TAPI object) 200, an address object 202, a terminal object 204, a call object 206, and a call-hub object 208. For each 25 of objects 202, 204, 206 and 208, only a single object of each type is shown in Figure 2 for purposes of clarity; however, there can be in one embodiment of the invention multiple instantiations of each of these objects. Each of the objects 202, 204, 206 and 208 may in one embodiment correspond to a specific means for performing functionality of the object.

The interface object 200 provides an interface by which computer programs can access the functionality provided by these other objects. This means that the computer programs themselves do not have to include code for this 30 functionality, but instead can rely on the functionality provided by the objects themselves as already existing, and as interfaced to such programs via the interface object 200. Application programming interfaces within operating

- 5 systems such as versions of the MICROSOFT WINDOWS operating system are known within the art.

The address object 202 is a type of first-party call control object. A call control object is an object that provides for the initiation and termination of a computer telephony call having a media stream -- that is, the object provides for
10 the connection and ending of a call. In particular, the address object 202 is an object over which a computer telephony call may be placed. That is, the address object 202 represents a line or device that can make or receive calls on it. In different embodiments of the invention, the object represents a modem attached to a PSTN (Public Switching Telephone Network) phone line, an ISDN (Integrated
15 Services Digital Network) hardware card attached to an ISDN line, a DSL (Digital Subscriber Loop) modem attached to a PSTN phone line having DSL capability, and an IP (Internet Protocol) address that is able to make IP telephony calls.
However, the invention is not limited to a particular representation. The address object 202 is a first-party call control object in that it relates to a party of the
20 telephony call -- for example, the caller or callee of the telephony call -- as opposed to a third party not specifically of the telephony call.

The terminal object 204 is a type of media control object. A media control object is an object that end-points the media stream of a computer telephony call. The media stream of a computer telephony call is the information that actually
25 makes up the call -- for example, audio information in the case of a voice call, audio and image (video) information in the case of a video call, etc. A media control object end-points the media stream in that it can be a sink object, which is a finishing end point such as speaker or a monitor where the media stream ends or is "sunk" after it has been communicated from one party to the call to another
30 party to the call, or a source object, which is a beginning end point such as a microphone or a speaker where the media stream begins or is "sourced" such that it is then communicated from one party to the call to another party to the call.

5 The terminal object 204 can represent physical devices, such as the microphone or speakers on a sound card, a video camera, and a phone, as well as more dynamic, virtual devices, such as a video window on the screen, a file to which the media stream is saved, and a DTMF (Dual Tone Multiple Frequency) detector.

The call object 206 is another type of first-party call control object. In
10 particular, the call object 206 represents an end-point of the computer telephony call. For example, for a caller to callee direct call, there would be two call objects 206, a first object representing the first end point of the call, and a second object representing the second end point of the call. In a conference call, there would be more than two call objects 206, one object 206 for each participant (end point).

15 The call-hub object 208 is a third-party call control object. The call-hub object 208 relates the call objects 206 for a particular computer telephony call. In other words, it represents a telephony connection itself, and is basically a collection of call objects that are all related because they are on the same telephony connection. For example, one type of call-hub object 208 is a tracking
20 object in a call center environment, to track the callers on a particular call, the duration of the phone call, etc. A third-party call control object is also able to initiate and terminate a phone call. However, the object is a third-party call control object in that it does not specifically relate to a particular party of the telephony call, but rather may encompass all the parties of the call (as well as
25 information regarding the call).

Referring next to Figure 3, a block diagram of an architecture according to one embodiment of the invention is shown. The architecture includes a TAPI application 300, the TAPI 302, a telephony server 304, a telephony service provider 306, a media stream provider 308, and a terminal manager 310. The
30 TAPI application 300 is a computer program that utilizes the functionality provided by the TAPI 302. That is, the TAPI application 300 is any type of computer program that utilizes the TAPI 302, through which the application is

- 5 able to access telephony call control and media control functionality provided by the TAPI 302.

The telephony server 304 and the telephony service provider 306 make up the call control aspects of the architecture of Figure 3. The telephony server 304 keeps track of all telephony capabilities on a given computerized system; for
10 example, such as that found within versions of the MICROSOFT WINDOWS NT operating system. The telephone service provider 306 is a component used to control a specific piece of telephony hardware. Although only one provider 306 is shown in Figure 3, the invention is not so limited; there can be many such providers installed.

15 The media stream provider 308 and the terminal manager 310 make up the media control aspects of the architecture of Figure 3. The media stream provider 308 is an extension of the provider 306, and works together with the provider 306 to implement call control (via the provider 306) and media control (via the provider 308). All call control requests proceed through the telephony server 304
20 to the provider 306, and all media control requests proceed through to the provider 308. The media stream provider 308 is a component used to control a specific media stream (such as audio, video, etc.). Furthermore, there is a media stream provider 308 for each different media stream; although only one provider 308 is shown in Figure 3, the invention is not so limited -- there can be many such providers installed.
25

The terminal manager 310 is a media control manager. It is a component that instantiates a medial control object for each installed multimedia device. That is, it is a component that allows telephony applications (such as application 300) to use any multimedia device installed within a telephony environment. When the
30 manager 310 is initialized, it discovers all multimedia devices that it can use that are installed on a given computer, such as sound cards, video capture cards, as well as other multimedia hardware; the invention is not so limited. The manager

- 5 than creates a medial control object, such as a terminal object, for each of these devices. The manager 310 also creates terminal objects or media control objects for other media sources or sink that do not necessarily correspond to hardware, but rather to virtual devices. These types of device represent media stream processing that is performed by the computer itself, rather than specific hardware.
- 10 10 For example, these types of terminals may include a video window, a speech recognition engine, and a file; the invention is not so limited.

The TAPI 302 in one embodiment has an interface that defines how the provider 308 communicates with the terminal manager 310. This interface allows any provider 308 (there may be more than one provider 308, although for

15 purposes of clarity only one is shown in Figure 3) to query the manager 310 for the devices that are represented as terminal or media control objects. The interface also allows the provider 308 to determine from the manager 310 how to include these devices within media streams that the provider 308 is to set up. Therefore, the manager 310 allows any provider 308 to access the same set of

20 terminal or media control objects, and use them with any telephony hardware.

Figure 4(a) shows a method for placing an outgoing computer telephony call according to an embodiment of the invention. Figure 4(b) shows a method for receiving an incoming computer telephony call according to an embodiment of the invention. In this section of the detailed description, exemplary methods according to embodiments of the invention are presented. This description is provided in reference to Figures 4(a) through 4(b). These exemplary methods are desirably realized at least in part as one or more programs running on a computer -- that is, as a program executed from a computer-readable medium such as a memory by a processor of a computer. The programs are desirably storable on a

25 computer-readable medium such as a floppy disk or a CD-ROM, for distribution and installation and execution on another (suitably equipped) computer.

30

5 Thus, in one embodiment, a computer program is executed by a processor
of a computer from a medium therefrom, where the program may include address
objects, call objects, terminal objects, and call-hub objects, as described in the
previous section of the detailed description. Each of these objects may in one
embodiment also correspond to a specific means for performing the functionality
10 of the object. In another embodiment, the computer program also includes a
terminal manager, which detects a plurality of multimedia devices and instantiates
a terminal object for each multimedia device detected, as has also been described
in the previous section of the detailed description.

15 Exemplary Methods

Referring now to Figure 4(a), a flowchart of a method for placing an outgoing computer telephony call, according to an embodiment of the invention, is shown. In 400, a TAPI object is instantiated by an application program so that the program is able to use the functionality provided by the TAPI. In 402, the TAPI
20 object is initialized. For example, a terminal manager is run to instantiate terminal objects for physical and virtual multimedia devices, as has been described in the previous section of the detailed description.

In 404, the TAPI object is queried for an enumeration of the address objects available from the TAPI object. Each address object has certain telephony capabilities -- for example, one may relate to an ISDN line, another to a PSTN line, etc. Thus, in 406, each address object is queried to learn its telephony capabilities. The desired address object or objects are then selected, depending on the type of call desired (e.g., a regular voice call may go over a PSTN line, a video call may go over one or more ISDN lines, etc.).
25

30 In 408, a call object is instantiated from a desired address object or objects. The call object thus relates to the computer performing the method of Figure 4(a) as being the caller for a specific computer telephony call utilizing the desired

5 address object or objects. In 410, the desired address object or objects are queried
for an enumeration of the terminal objects available from the address object or
objects. For example, an address object relating to a PSTN line over which voice
calls are placed may have a terminal object relating to a microphone and a
terminal object relating to a sound card connected to a speaker. Depending on the
10 type of call desired, then, in 412 at least one desired terminal object enumerated in
410 is selected. Finally, in 414, the outgoing computer telephony call is
connected (i.e., placed) over the desired address object or objects utilizing the
desired terminal object or objects.

Thus, placing a computer telephony call according to the embodiment of
15 the invention of Figure 4(a) involves determining the address objects that are
available such that a call may be placed over them, and selecting a desired address
object or objects. A call object is created for the specific call to be placed. The
terminal objects that are available for the utilized address objects are then
determined, and the desired terminal objects are selected. The call is then placed,
20 such that the address objects represent the communication media over which the
call is placed, and the terminal objects represent the multimedia devices that act as
end points for the media stream communicated over the communication media.

Referring next to Figure 4(b), a flowchart of a method for receiving an
incoming computer telephony call, according to an embodiment of the invention,
25 is shown. In 450, a TAPI object is instantiated by an application program so that
the program is able to use the functionality provided by the TAPI. In 452, the
TAPI object is initialized. For example, a terminal manager is run to instantiate
terminal objects for physical and virtual multimedia devices, as has been described
in the previous section of the detailed description.

30 In 454, the TAPI object is queried for an enumeration of the address
objects available from the TAPI object. Each address object has certain telephony
capabilities -- for example, one may relate to an ISDN line, another to a PSTN

5 line, etc. Thus, in 456, each address object is queried to learn its telephony capabilities. The desired address object or objects are then selected, depending on the type of call that is desired to be listened for (e.g., a regular voice call may be received over a PSTN line, a video call may be received over one or more ISDN lines, etc.).

10 In 458, an event callback is instantiated and registered on the TAPI object. The event callback is a request by the application program performing the method of Figure 4(b) to have the TAPI object notify the application program when the desired event occurs -- in this case, when an incoming call is received. In 460, the desired address object or objects are also registered with the TAPI object. These
15 are the address object or objects over which an incoming computer telephony call is to be listen for by the TAPI object, such that upon occurrence of such an event, the application program performing the method of Figure 4(b) is notified. Thus, in 462, a notification of an incoming computer telephony call from the TAPI object is received on the event callback. In 464, the incoming computer telephony
20 call is connected (i.e., received) over the desired address object or objects.

As has been described, receiving a computer telephony call according to the embodiment of the invention of Figure 4(b) involves determining the address objects that are available such that a call may be received over them, and selecting a desired address object or objects. An event callback is created and registered, so
25 that notification is received when a call arrives over the desired address object or objects. The call is then received (created), such that the address objects represent the communication media over which the call is received.

Speech Processing

30 Figure 5 is a block diagram of a system according to one aspect of the present invention. A system 500 is an interactive voice response system that is used to collect and provide information for a caller. When a caller calls the

5 system 500, the call is answered automatically. The system 500 presents the caller with a number of choices that the caller can select by pressing the keypad of the caller's telephone or by voice. If the system 500 determines that it is necessary for the caller to communicate to a human agent, the call is then routed to the client computer of the human agent so that the human agent can answer.

10 The system 500 includes a telephony source 502. The telephony source 502 generates a telephony call that is transmitted by a public switched telephone network 504. The public switched telephone network 504 transmits the telephony call to a gateway 506. The gateway 506 translates the telephony call based on the communication protocols of the public switched telephone network 504 to a
15 telephony call based on internet protocols. The gateway 506 transmits the internet protocol telephony call to a call router 510. The call router 510 may store information associated with the internet protocol telephony call in a data store 514.

The call router 510 routes the internet protocol telephony call to an interactive voice response server 512. In one embodiment, the interactive voice
20 response server 512 includes a terminal object. In another embodiment, the interactive voice response server 512 performs media processing tasks, such as playing prerecorded messages and detecting input from the user. In one embodiment, such media processing tasks can be accomplished using an appropriate instantiation of the terminal object. The interactive voice response
25 server 512 may store information associated with the internet protocol telephony call in the data store 514. The interactive voice response server 512 decides to allow the call router 510 to route the internet telephony call to a client computer 516 depending on a caller's interaction with the interactive voice response server 512.

30 The client computer 516 is adapted to retrieve information associated with the internet protocol telephony call from the data store 514. In one embodiment, the client computer 516 includes a terminal object. The terminal object allows the

5 client computer to answer the internet protocol telephony call.

Figure 6 is a block diagram of a system according to one aspect of the present invention. A system 600 is a unified messaging system that allows voice mail to be saved as a computer file so that the voice mail can be accessed through an email system.

10 The system 600 includes a telephony source 602. The telephony source 602 generates a telephony call that is transmitted to a gateway 604. The gateway 604 translates the telephony call to a telephony call based on internet protocols. The gateway 604 transmits the internet protocol telephony call to a client computer 610. If the client computer 610 is unavailable to answer the internet protocol
15 telephony call, the internet protocol telephony call is routed to a voice mail system 606. In one embodiment, the voice mail system 606 includes a terminal object.

The voice mail system 606 saves the voice mail in the email store. The client computer 610 receives an email message with the voice mail saved as an attachment. The client computer 610 may then access the voice mail through the
20 media processing capability of the client computer 610.

Figure 7 is a block diagram of a system according to one aspect of the present invention. A system 700 illustrates speech-enabled Web applications. The system 700 allows Web content and services to be accessed through telephony connections and rendered as speech rather than as text or graphics.

25 The system 700 includes a client 702. The client 702 initiates a telephony call to a voice browser 704 that is executing on a computer. The voice browser 704 can access at least one Web page 708 stored on a Web server 710. The Web page 708 may include voice tags. In one embodiment, the voice browser 704 includes a terminal object that can interpret the voice tags. In another
30 embodiment, the terminal object renders the Web page 708 into speech for the client 702. In another embodiment, the terminal object allows the client to navigate through a Web site based on the speech commands of the client.

5 Figure 8 is an object diagram of a collection of objects according to one aspect of the present invention. An object hierarchy 801 includes objects that are similar to objects discussed hereinbefore. For clarity purposes, discussion relating to those similar objects is incorporated in full here.

The object hierarchy 801 includes a TAPI object 800, a call-hub object
10 802, an address object 804, a call object 806, a terminal object 808, and a stream object 810. These objects have been discussed hereinbefore. The object hierarchy 801 includes a speech recognition object 812 that is derived from the terminal object 808. In one embodiment, the terminal object 808 can be viewed as a terminal data structure, and the speech recognition object 812 is a speech
15 recognition data structure that extends the terminal data structure. The object hierarchy 801 also includes a speech generation object 814 that is derived from the terminal object 808. In one embodiment, the terminal object 808 can be viewed as a terminal data structure, and the speech recognition object 814 is a speech recognition data structure that extends the terminal data structure.

20 Figure 9 is a structural diagram of a data structure according to one aspect of the present invention. A data structure 900 supports speech recognition. The data structure 900 includes a number of data structures to help the process of speech recognition. These data structures include an engine token data structure 902, an enumeration engine data structure 908, a speech recognition data structure 25 912, and a recognition context data structure 922.

The engine token data structure 902 includes a method member get engine name 904. The method member get engine name 904 gets the name of a speech recognition engine in a textual form. The engine token data structure 902 includes a method member get engine token 906. The method member get engine token
30 906 gets an identifier that identifies a speech recognition engine.

5 The enumeration engine data structure 908 includes a method member next
910. The method member next 910 gets the next available speech recognition
engine from a list of available speech recognition engines.

The speech recognition data structure 912 includes a method member
enumerate recognition engines 914. The method member enumerate recognition
10 engines 914 obtains an indirect reference to a listing of speech recognition engines
that are available for use. The speech recognition data structure 912 includes a
method member select engine 916. The method member select engine 916 selects
a speech recognition engine to be used in the speech recognition process. The
speech recognition data structure 912 includes a method member get selected
15 engine 918. The method member get selected engine 918 retrieves the currently
selected speech recognition engine. The speech recognition data structure 912
includes a method member convert extended markup language to grammar 920
converts extended markup language (XML) into a compiled grammar for use with
a speech recognition engine.

20 The recognition context 922 includes a method member initialize 924. The
method member initialize 924 creates a speech recognition context based on a
selected speech recognition engine. The recognition context 922 includes a method
member shut down 926. The method member shut down 926 destroys a speech
recognition context. The recognition context 922 includes a method member load
25 grammar 928. The method member load grammar 928 loads a grammar into a
recognition context from a source selected from a group consisting of a resource, a
memory, and a file. The recognition context 922 includes a method member
unload grammar 930. The method member unload grammar 930 unloads a
grammar previously loaded into a recognition context. The recognition context
30 922 includes a method member activate grammar 932. The method member
activate grammar 932 activates a grammar to be used in a speech recognition
engine. The recognition context 922 includes a method member get result 934.

5 The method member get result 934 retrieves a speech recognition result. The
recognition context 922 includes a method member get hypothesis 936. The
method member get hypothesis 936 retrieves a speech recognition result that is
deemed a likely speech recognition result.

Figure 10 is a process diagram of a method according to one aspect of the
10 present invention. A process 1000 is a method for enhancing media processing.
The process 1000 includes an act 1002 for selecting a speech recognition terminal
object. The process 1000 includes an act 1004 for requesting a speech recognition
terminal object.

The process 1000 includes an act 1006 for getting a desired speech
15 recognition engine. The act 1006 includes an act for enumerating a list of
available speech recognition engines, an act for identifying a desired speech
recognition engine from the list of available speech recognition engines, and an act
for selecting the desired speech recognition engine.

The process 1000 includes an act 1008 for setting a speech recognition
20 context. The act 1008 includes an act for initializing the speech recognition
context, an act for loading a grammar for the speech recognition context, and an
act for setting the speech recognition context to notify a user when a desired event
occurs.

Figure 11 is a structural diagram of a data structure according to one aspect
25 of the present invention. A data structure 1100 supports speech generation. The
data structure 1100 takes a text string and renders such a text string into speech.
The data structure 1100 allows a voice to be selected to speak the rendered speech.

The data structure 1100 includes a set of voice method members that are
selected from a group consisting of a method member set voice 1102 for setting a
30 voice to be used for speech generation and a method member get voice 1104 for
getting the voice used in speech generation. The data structure 1100 includes a set
of priority method members that are selected from a group consisting of a method

5 member set priority 1106 for setting a priority for a voice and a method member
get priority 1108 for getting a priority for a voice. The voice with a higher
priority may interrupt a voice with a lower priority. The data structure 1100
includes a set of volume method members that are selected from a group
consisting of a method member set volume 1110 for setting a volume of speech
10 synthesized by a speech engine and a method member get volume 1112 for getting
a volume of speech synthesized by a speech generation engine. The data structure
1100 includes a set of rate method members that are selected from a group
consisting of a method member set rate 1114 for setting a rate of speech
synthesized by a speech generation engine and a method member get rate 1116 for
15 getting a rate of speech synthesized by a speech generation engine. The data
structure 1100 includes a set of time out method members that are selected from a
group consisting of a method member set time 1118 for setting a time for a speech
synthesis to time out and a method member get time 1120 for getting a time for a
speech synthesis to time out.

20 The data structure 1100 includes a method member speak 1128 for
synthesizing text to audio. The data structure 1100 includes a method member get
status 1122 for getting a status on synthesizing of output audio. The data structure
1100 includes a method member skip 1124 for skipping to a specific point in a text
stream. The data structure 1100 includes a method member wait 1126 for blocking
25 other executions until the method member speak 1128 has been executed to
completion. The data structure 1100 includes a method member enumerate voices
1130 for obtaining a list of voices for the speech generation engine.

The method member speak 1128 is receptive to a number of inputs so as to
enhance the synthesis of text to audio. These inputs include a text stream with
30 voice markup, an offset that represents an offset into the text stream where the
voice should start speaking, a speakover flag so as to blend the voice output over

- 5 any currently playing audio output, and a punctuation flag so as to allow a speech generation engine to speak each punctuation of a text stream.

Figure 12 is a process diagram of a method according to one aspect of the present invention. A process 1200 is a method for enhancing media processing.

- The process 1200 allows speech generation. The process 1200 includes an act
10 1202 for requesting a speech generation terminal object. The process 1200 includes an act 1204 for selecting a voice. The act 1204 includes an act for enumerating a list of available voices and an act for identifying a desired voice from the list of available voices. The process 1200 includes an act 1206 for generating a speech. In one embodiment, the act 1206 generates the speech from a
15 text stream that includes voice markup.

Conclusion

Computer telephony application programming interface has been described.

- Although the specific embodiments have been illustrated and described
20 herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiments shown. This application is intended to cover any adaptations or variations of the present invention. It is to be understood that the above description is intended to be illustrative, and not restrictive. Combinations
25 of the above embodiments and other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention includes any other applications in which the above structures and fabrication methods are used. Accordingly, the scope of the invention should only be determined with reference to the appended claims, along with the full scope of
30 equivalents to which such claims are entitled.